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B66C 23/88

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(54) Method for ensuring safe operation of mobile boom crane and system for implementing it

(57) In a method for ensuring safe operation of a mobile boom crane, stability signals are produced by transducers (4 to 10) of supports and axles while crane strength signals are produced by transducers (14 to 16) of the crane units. The stability signals are grouped by a unit (11) which monitors the crane setting and is connected to a control unit 12 connected to an actuating device 13 of the crane. The crane strength signals are also connected to the control unit 12. Crane setting safe operation signals are generated and compared with their minimum levels while the crane strength signals are compared with their maximum levels to generate inhibit or enable signals and feed them to the crane actuating device (13) in the event one of the stability or strength signals is outside its allowable range.

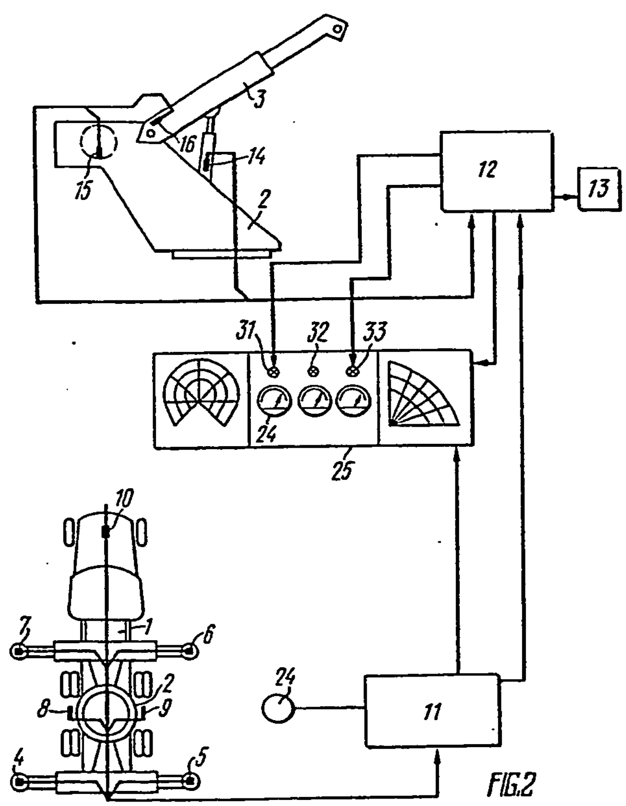

FIG.2

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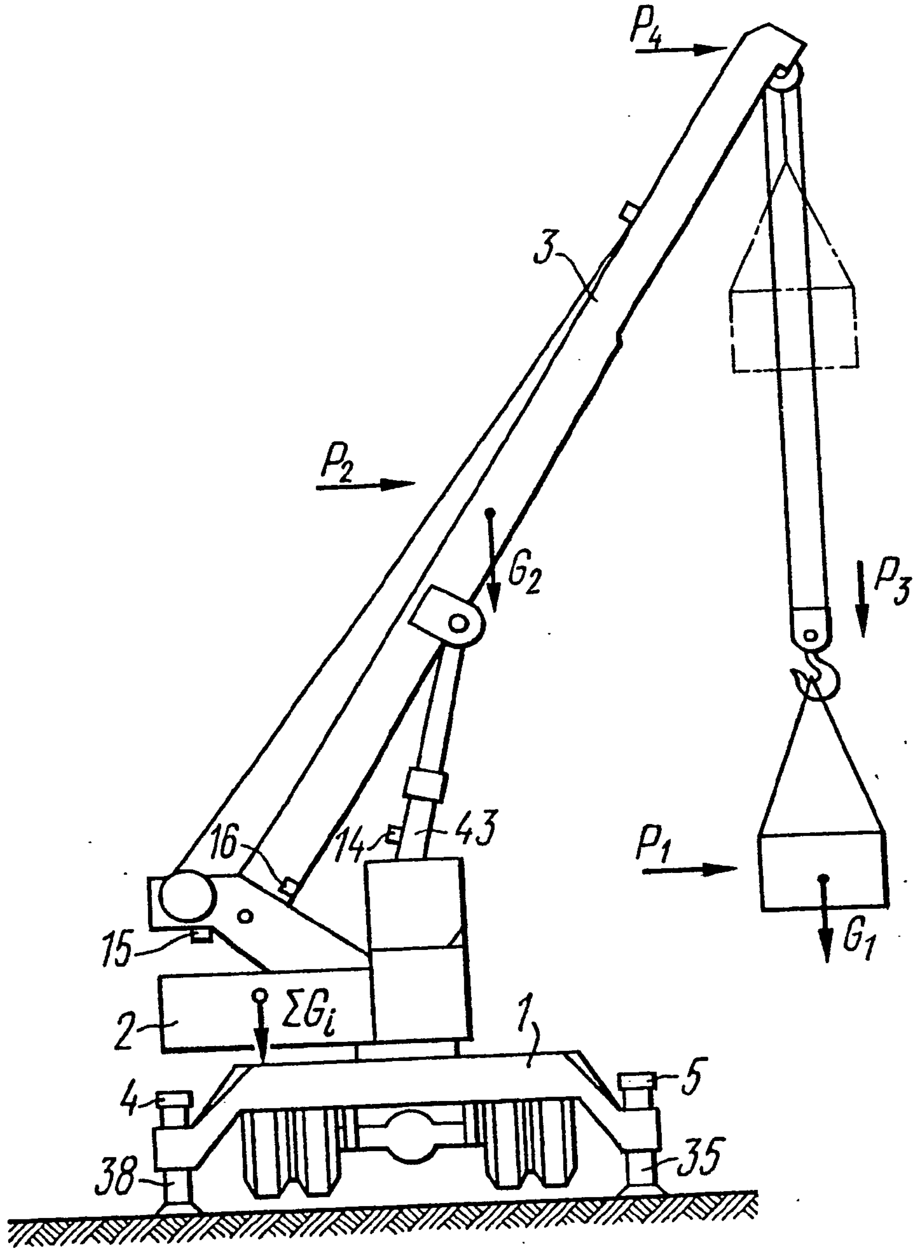

FIG.1

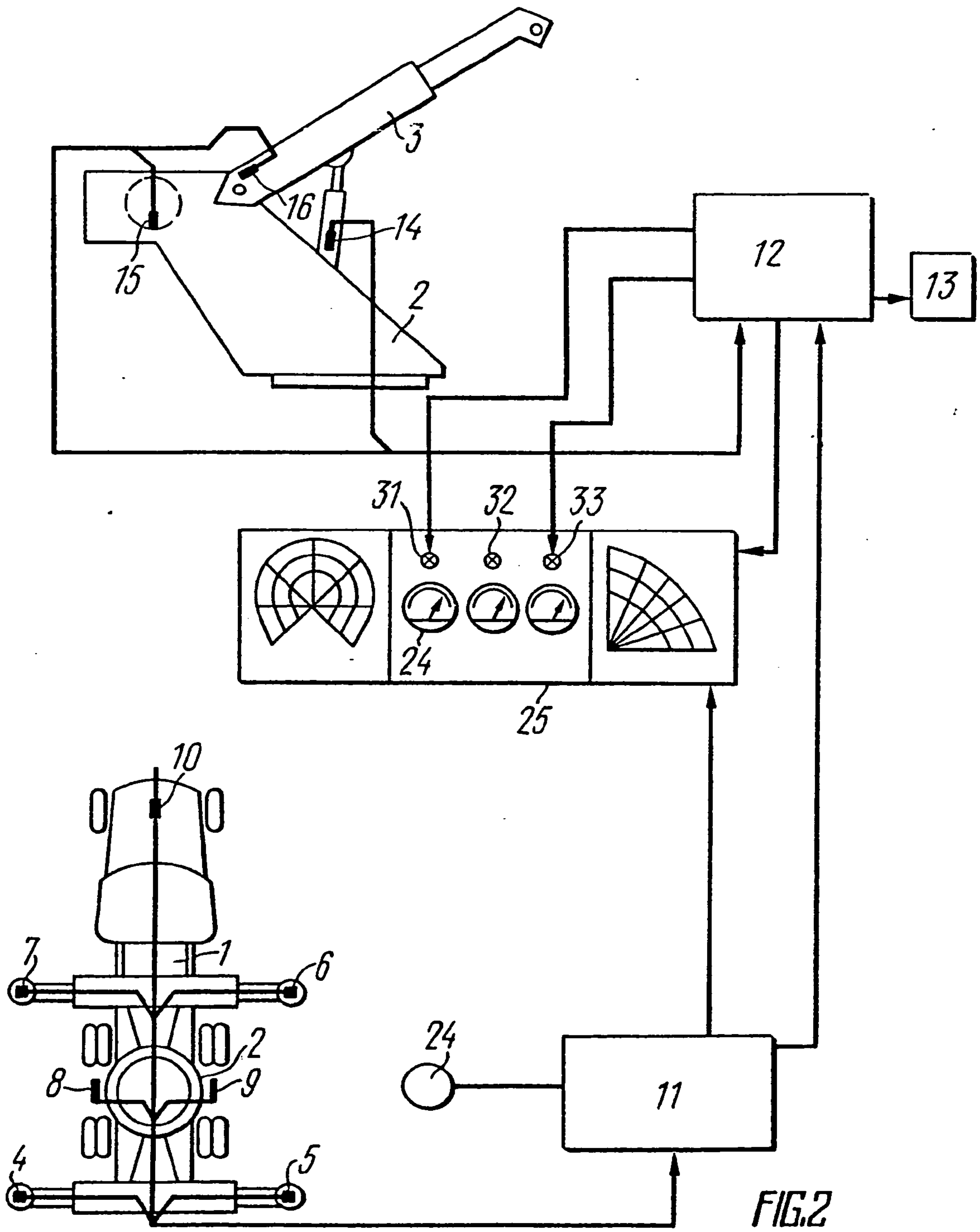

FIG.2

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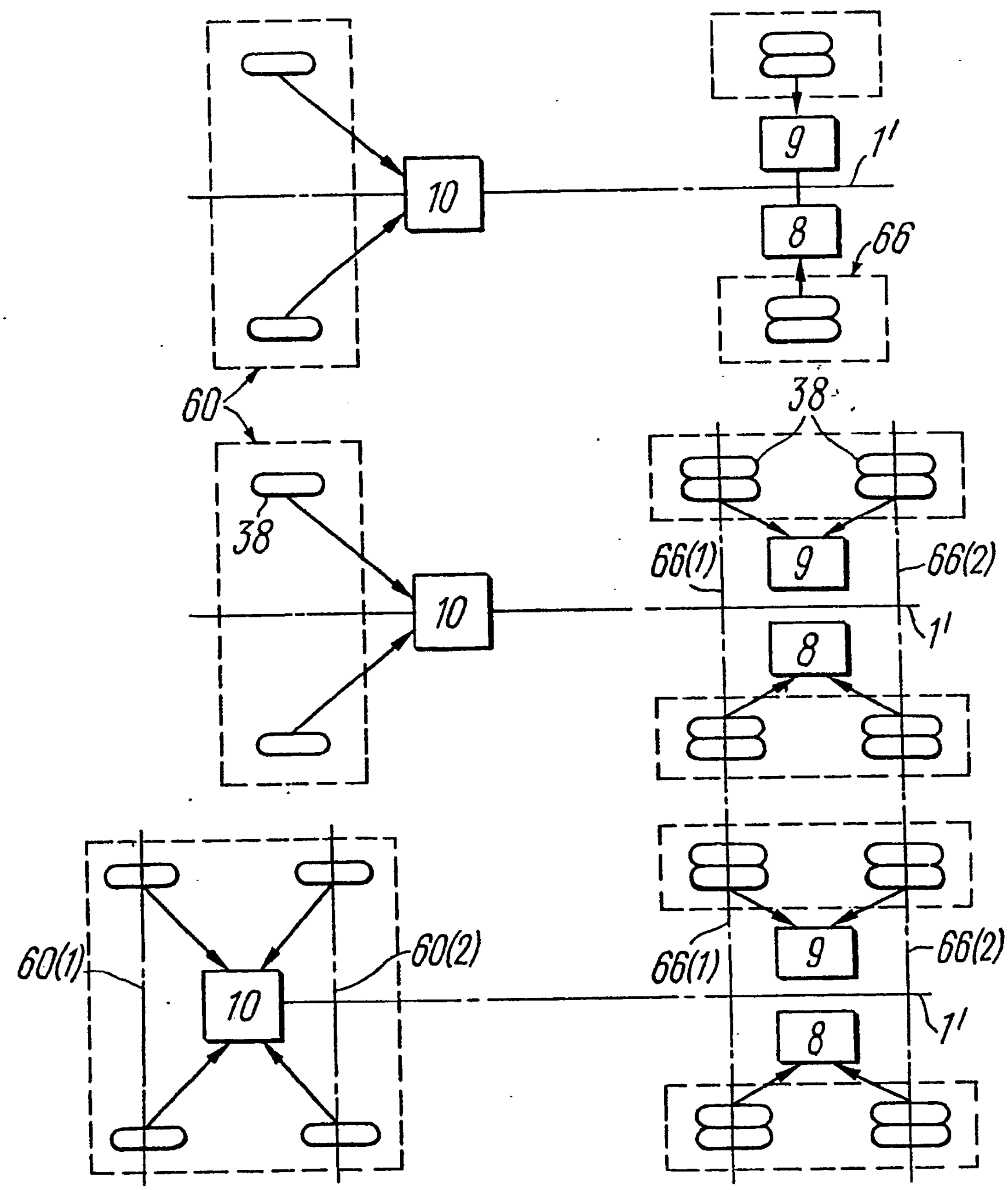

FIG.3

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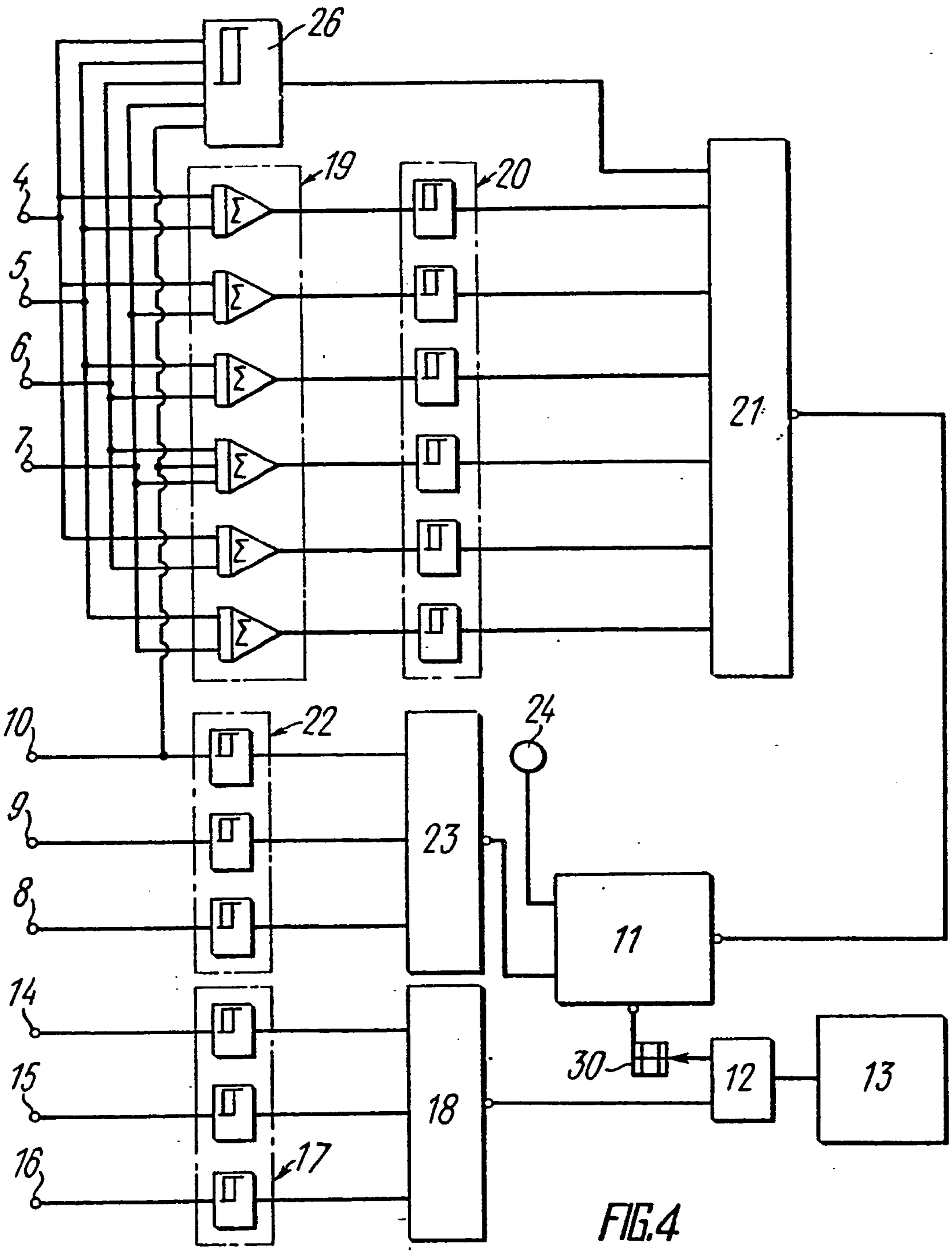

FIG.4

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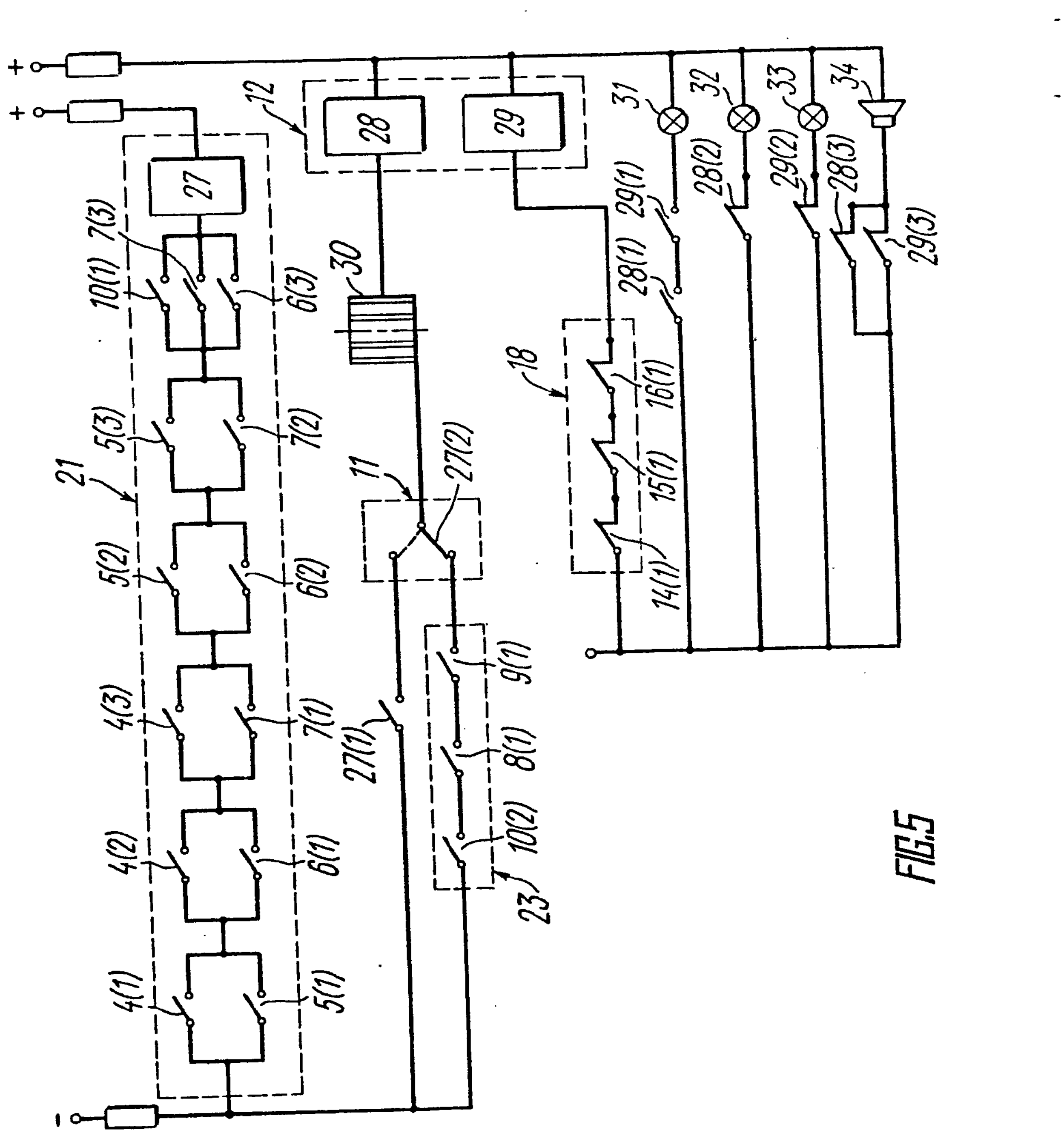

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FIG.5

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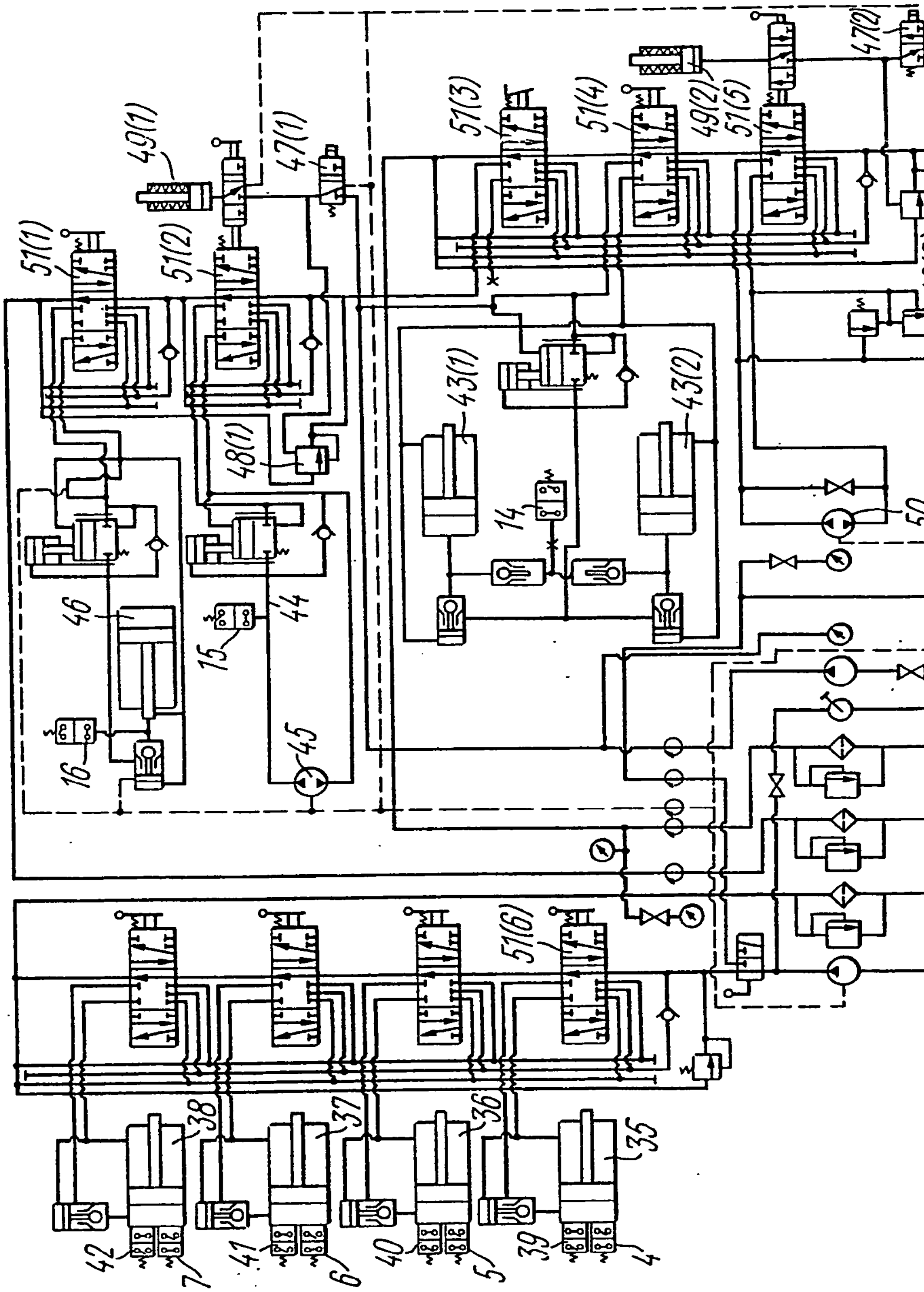

FIG.6

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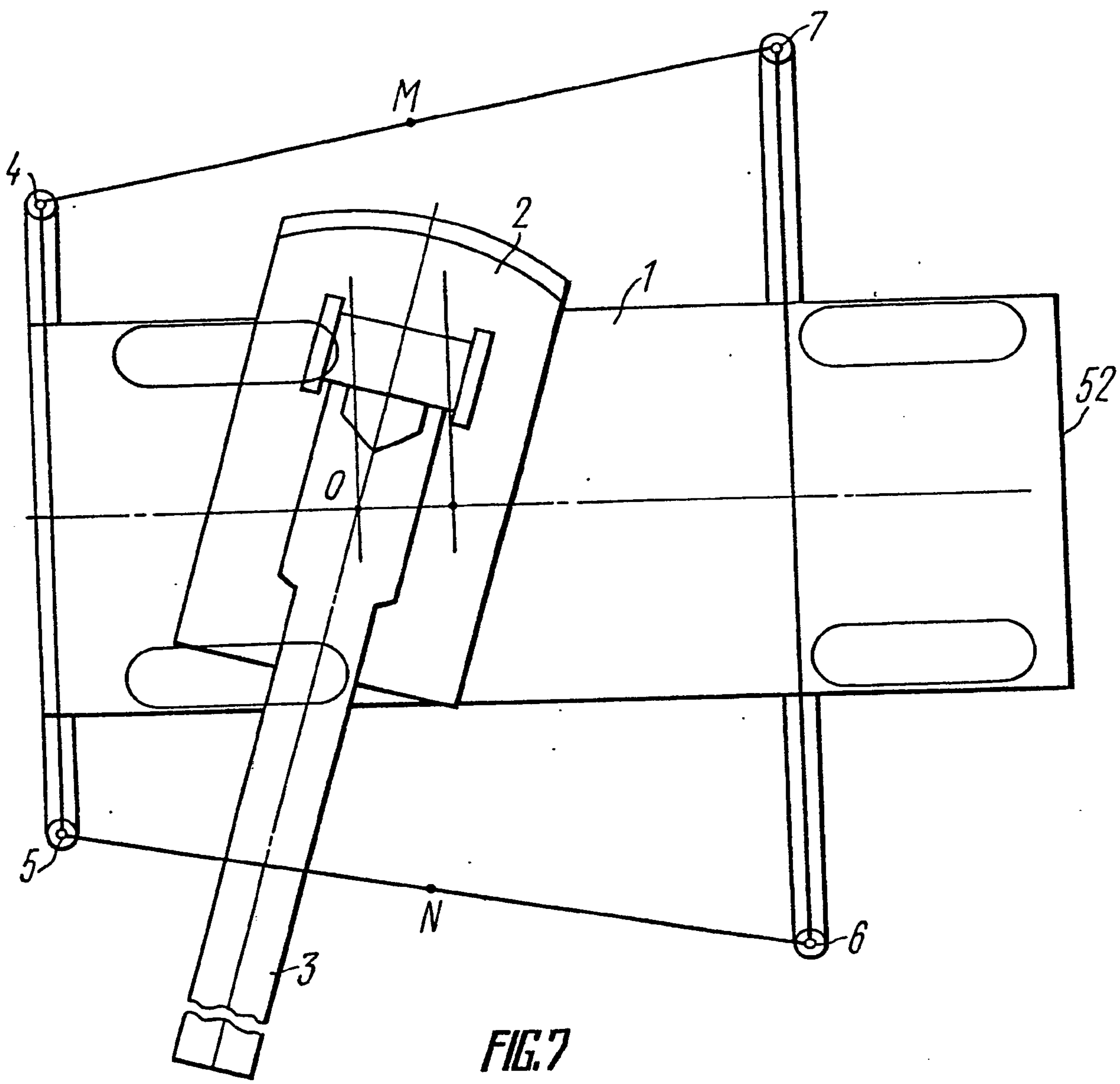

FIG.7

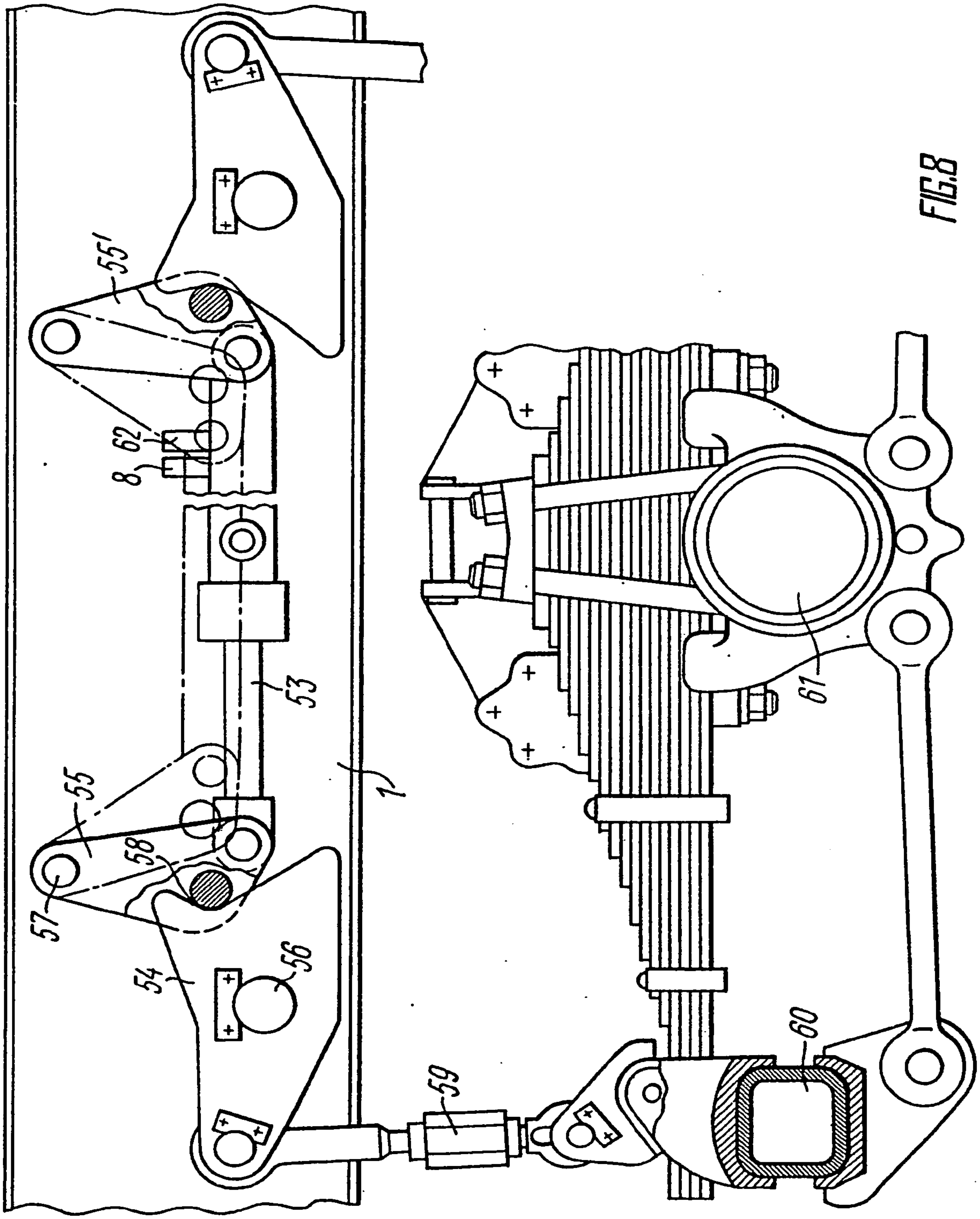

FIG.8

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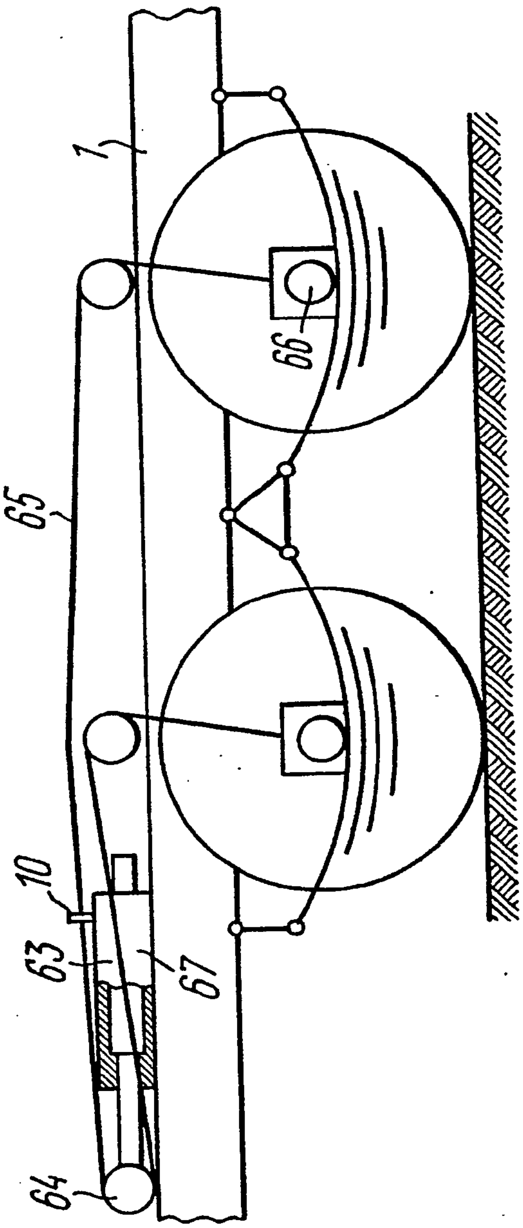

FIG.9

SPECIFICATION

Method for ensuring safe operation of mobile boom crane and system for implementing it

The present invention relates to civil engineering, and more specifically, to ensuring safe operation of a mobile boom crane.

The invention may be used to the best advantage in a mobile boom crane with a telescopic boom and additional hydraulically-controlled supports.

It may likewise be used in cranes with lattice booms, in robot cranes, erecting towers, self-propelled hoists, and other boom machines comprising additional hydraulically-controlled supports to ensure the stability thereof in operation.

The essence of the invention consists in providing a method for ensuring safe operation of a mobile boom crane, whereby signals are generated in support transducers, to be converted into stability signals characterizing the crane stability, maximum levels of the converted signals ensuring the crane safe operation are generated and compared with the crane stability signals and, depending on the results of comparison, an inhibit or enable signal is produced and fed to an actuating device of the crane.

According to the invention, additional signals are shaped in transducers fitted in the crane axles, to be converted into stability signals characterizing the crane stability, the stability signals formed in the transducers of supports and axles are united in one of the groups characterizing the crane setting on the ground, and the stability signals are compared with the minimum levels thereof in each group, signals being simultaneously shaped in transducers installed in the crane units, to be converted into strength signals characterizing the strength of the crane units, and compared with the maximum preset levels, whereas the inhibit signals are generated in the event of one of the stability or strength signals exceeding its maximum level.

Such a solution makes it possible to take account of the status of the crane positioning on supports, without supports or with partial use of supports, and also permits monitoring of the requisite standardized parameters, e.g., strength of units, thereby contributing to higher operational safety and efficiency of the crane. Moreover, comparing the stability signals with the minimum levels thereof, i.e. with respect to the supports relief, characterizes in the maximum degree the crane stability, and enhances the accuracy and improves the stability monitoring.

According to one embodiment of the invention, the stability signals shaped in the transducers of supports and axles are united in one of the groups as regards signal intensity, with the first group being made up of the stability signals formed in the transducers of the supports and a front axle, the second group, of signals generated in the transducers of the front axle, the third group, of signals produced in the transducers of the rear axle, located on one side of the longitudinal axis of the crane chassis, and the fourth group, of signals formed in the transducers of the rear axles, located on the other side of the longitudinal axis of the crane chassis.

Such a solution contributes to a higher operational safety of the crane, because it takes into consideration the influence exerted by the positioning of (load on) the front axle and rear axles, with the crane operating radius consituting 360°.

According to another embodiment of the system to implement the proposed method, the system comprises the stability transducers fitted in the supports in association, through adders and comparators, with the crane actuating device generating an inhibit or enable signal, and is provided with additional stability transducers installed in the crane axles, the strength transducers fitted in the crane units to indicate the maximum load of the crane, a unit to monitor the crane setting, whose input is connected to the stability transducers of the supports and axles through comparators of the minimum signal level and the output to one input of a control unit with the output thereof associated with the crane actuating device, and an OR unit with the output thereof connected to the strength transducers and the output thereof associated with the other input of the control unit.

According to the invention, there are proposed two embodiments of the system, one using analog transducers, and the other, threshold converters.

In the first embodiment of the invention, analog stability and strength transducers are grouped in a manner that each pair out of the likely combinations of pairs of support transducers (including those arranged on the diagonal of the figure formed by the supports) is connected to its own adder, the input of the adder of the front support transducers is also associated with the transducer of the front axle, the output of each adder is associated with its own minimum signal level comparator, the outputs of the comparators are connected to the unit to monitor the crane setting through an OR circuit, and the transducer of the front axle, and also the transducers of the rear axles, located on both sides of the longitudinal axis of the crane chassis are associated with their own comparators of the minimum signal level, with the outputs thereof being associated with the unit to monitor the crane setting through their own OR circuit, and all strength transducers are connected to their own OR unit through their own maximum signal level comparators.

In the other embodiment of the invention, the stability and strength transducers are provided with threshold converters comprising contact pairs, and closing contact pairs of supports are interconnected in parallel in accordance with the number of likely combinations of pairs of support transducers, and all pairs are series-connected in a support circuit with the their own support relays, the pairs of front supports being connected in parallel with a closing contact pair of the transducer of the front axle, and the other closing contact pair of the transducer of the front axle and closing pairs of the transducers of the rear axles located on both sides of the longitudinal axis of the crane chassis are series-connected in a circuit of axles, the support relay contains the closing contact pair and make-before-break contacts with a common contact thereof connected to the input of one of the relays whose output is associated with the

crane actuating device and two other contacts - an opening and a closing ones - are respectively connected to the axle circuit and the closing contact pair of the support relay, and the opening contact pairs of the strength transducers are series-connected with each other and with the input of a second relay with the output thereof associated with the crane actuating device.

The second embodiment of the invention, i.e. the one comprising threshold converters, allows the system to be considerably simplified, thereby making the use thereof expedient even on small load-lifting capacity cranes, e.g. truck cranes, which will ensure their operational safety and enhance efficiency.

An alternative embodiment of the invention may include a combination-type system, using individual transducers, e.g. stability transucers, provided with threshold converters.

It is expedient that the support stability transducers be arranged in such a way that the supports form a trapezoidal figure with the larger base thereof constituted by the crane front supports located beyond the boom radius.

In the event of truck cranes wherein work under the cab is prohibited and the range of the boom operating radii is limited, this allows the crane capabilities as regards stability and strength of units to be used in a fuller degree, thereby enhancing the crane efficiency both with respect to the load-lifting capacity and under-boom space.

It is desirable that the transducers of the rear axles be mounted on a hydraulic power cylinder kinematically associated with the rear axle, wherethrough the bearing pressure is imparted to the suitable transducers.

Such a solution makes it possible to derive a signal on a loaded state of the rear axle and to install a rear axle transducer on the crane.

It is practicable that the front axle transducer be mounted on a hydraulic power cylinder kinematically associated with the front axle imparting its bearing pressure to the suitable transducer.

This solution makes it possible to obtain a signal on a loaded state of the front axle and to mount a front axle transducer on the crane.

The invention will now be described in terms of specific embodiments thereof - systems implementing the proposed method - with reference to the accompanying drawings, wherein:

Figure 1 is a schematic representation of the general view of a mobile boom crane with loads acting upon it in operation, and with transducers arranged according to the invention;

Figure 2 shows the arrangement of transducers on the crane according to the invention and connection thereof with units of the crane protection system;

Figure 3 schematically represents versions of grouping the signals of axle transducers in different embodiments of the crane, according to the invention;

Figure 4 illustrates a block diagram of the system with analog transducers, according to the invention;

Figure 5 shows a circuit diagram of the system with threshold converters, according to the invention;

Figure 6 represents a flow diagram with transducers fitted in hydraulic units of the crane;

Figure 7 is a schematic diagram of a trapezoidal support figure;

Figure 8 shows an interlock mechanism of the rear axle for installation of a transducer;

Figure 9 illustrates a front axle transducer being installed on the crane.

A mobile boom crane (Figure 1) comprises a chassis 1 and slewing circle 2 with a boom 3. An operating crane is subjected to the action of a combination of loads, e.g. mass of load (G_1), mass of boom (G_2), effect of wind on load (P_1) and on boom (P_2), inertial loads (P_3) and (P_4), and other loads capable of overturning the crane or breaking one of the units thereof (boom, support, slewing circle and the like). The crane stabilizing moment depends on that action of a sum ΣG_i of masses.

The criterion of the crane stability is a condition when the sum of reactions of the crane bearing members (supports and axles) located off the tilting line is superior to zero.

A safety system of a crane, according to the invention, ensuring its safe operation as regards tilting and strength of units comprises stability transducers 4, 5, 6, 7 (Figure 2) of the crane supports, transducers 8, 9 (Figures 2, 3) of the rear axle, located on both sides of an axis 1' (Figure 3) of the crane chassis 1, and a transducer 10 of the front axle, all transducers 4, 5, 6, 7, 8, 9, 10 are connected to a unit 11 (Figure 2) to monitor the crane setting, with the output thereof associated with one of the inputs of a control unit 12 connected to an actuating device 13 of the crane. The system also contains strength transducers, e.g. a force transducer 14 in the boom lift hydraulic cylinder, a force transducer 15 in the load rope, and a force transducer 16 in the boom extension hydraulic cylinder, which are connected to another input of the control unit 12 through maximum level comparators 17 (Figure 4) and their own OR circuit 18.

Strength transducers may also be mounted in supports to prevent breakage thereof, and in axles for protection against overloading of the same. They may be made in the form of an inclinometer to limit the crane inclination, in the form of an anemometer to offset the action of the wind upon the crane, or in any other convenient manner, their connections being similar to those of the transducers 14, 15, 16.

In the event of the stability transducers 4, 5, 6, 7, 8, 9, 10 (Figure 4) and the strength transducers 14, 15, 16 being of an analog type, according to the invention, the support transducers 4, 5, 6, 7 are paired in a manner that each pair out of the likely combination of pairs of the support transducers 4, 5, 6, 7 is connected to its own adder 19, the input of the adder of the front support transducers 6, 7 being also associated with the front axle transducer 10. The output of each adder 19 is associated with its own minimum signal level comparator 20. The outputs of the comparators 20 are connected to the unit 11 to monitor the crane setting through an OR circuit 21, and the front axle transducer 10, as well as the rear axle transducers 8, 9 located on both sides of the longitudinal axis 1' (Figure 2) of the crane chassis, are

associated with their own minimum signal level comparators 22 (Figure 4), with the outputs thereof being associated with the unit 11 to monitor the crane setting through their own OR circuit 23, and all the strength transducers 14, 15, 16 are connected to their own OR circuit 18 through their own maximum signal level comparators 17. The system may also include a crane setting indicator 24 located on the crane control panel (Figure 2) in the operator's cab, and also by the support distributor. For additional information on the crane condition the block diagram may also comprise an adder 26 (Figure 4) of all the transducers 4, 5, 6, 7 and of the front axle transducer 10.

In the event of the transducers being provided with threshold converters the circuit diagram of the system, according to the invention, also contains the control unit 12 (Figure 5), the unit 11 to monitor the crane setting, and the OR circuits 18, 21, 23. The closing contact pairs 4 (1, 2, 3), 5 (1, 2, 3), 6 (1, 2, 3), 7 (1, 2, 3) of the supports 4, 5, 6, 7 are interconnected in parallel in accordance with the number of likely combinations of pairs of support transducers, all pairs being series-connected in a support circuit to form the OR 21 circuit or with their own support relay 27. The pairs 6(3) to 7(3) of the front support transducers are connected in parallel with a closing contact pair 10(1) of the front axle transducer 10. The other closing contact pair 10(2) of the front axle transducer 10 and closing pairs 8(1) and 9(1) of the rear axle transducers 8, 9 located on both sides of the longitudinal axis of the crane chassis are series-connected in a circuit of axles to form the OR circuits. The support relay 27 contains the closing contact pair 27(1) and make-before-break contacts 27(2) with a common contact thereof connected to the input of one of relays 28 of the control unit 12, whose output is connected to the crane actuating device (omitted, being shown in the circuit diagram), and two other contacts - an opening and a closing ones - are respectively connected to the OR circuit 23 and the closing contact pair 27(1) of the support relay 27. The opening contact pairs 14(1), 15(1), 16(1) of the strength transducers 14, 15, 16 are series-connected with each other to form the OR 18 circuit, and with the input of a second relay 29 of the unit 12, with the output thereof being also associated with the crane actuating device.

As the support and axle transducers are located on the chassis 1 (Figure 2) of the crane, and the control panel 25, the control panel 12 and the actuating device 13 are arranged on the crane slewing circle 2, they are interconnected by means of a current collector 30 (Figures 4, 5). Besides, the control panel 25 (Figure 2) may include various information instruments and light indication, e.g. green and red lamps. In this case a green lamp 31 (Figures 2 and 5) is controlled by the contacts 28(1) and 29(1) of the relays 28, 29, whereas information on the nature of the danger facing the crane is issued separately by a red lamp 32 as regards stability and a red lamp 33 as regards strength, and by the contact pairs 28(2) and 29(2). A sound signal 34 (Figure 5) may be fitted in a similar manner.

The crane stability transducers 4 to 7 may be installed in their own hydraulic cylinders 35, 36, 37, 38 (Figures 1, 6) of the supports together with support strength transducers 39, 40, 41, 42 (Figure 6). The hydraulic cylinders 35, 36, 37, 38 are controlled by their own control valves. The transducer 14 is associated with the head ends of a boom lift hydraulic cylinder 43. The transducer 15 may be fitted in a pressure line 44 of a hydraulic motor 45 of the load winch with the latter operating in the lift mode, and the transducer 16 may be provided in a hydraulic cylinder 46 meant for extending the boom sections. The crane actuating device 13 may be made in the form of a hydraulic control valve 47(1) or 47(2) controlled by the control unit 12, comprising, e.g. the relays 28, 29 (Figure 5).

The hydraulic control valves 47(1) and 47(2) (Figure 6) are associated with a hydraulic line controlling valves 48(1) and 48(2), and with hydraulic cylinders 49(1) and 49(2), respectively, of the brakes of a hydraulic motor 50 of the crane slewing mechanism and of the motor 45 of the winch mechanism, which are controlled by their own hydraulic control valves 51(1) to 51(5), while the values 51(6) control the hydraulic cylinders of the supports.

In accordance with one embodiment of the invention, the plan view of the transducers 4, 5, 6, 7 with the support hydraulic cylinders 35, 36, 37, 38 represents a trapezoid with the larger base thereof formed by the front supports with transducers 6, 7 (Figure 7), on the side of a crane driver's cab 52.

The trapezoidal arrangement of the supports with the stability transducers on the side of the cab 52 allows the crane stability and strength characteristics to be used in a fuller degree owing to a balanced load stability factor with different positions of the boom in relation to the circuit 6, 5, 4, 7.

Such a solution has become practicable due to the use of a crane safe operation system implementing, according to the invention, a novel principle to monitor the crane stability with respect to relieving the supports.

According to one embodiment of the invention, the rear axle transducers are mounted on a hydraulic cylinder kinematically associated with the rear axle, wherethrough the bearing pressure of the rear axles is imparted to the suitable transducers.

More specifically, the transducer 8 (Figure 8) or 9 of the rear axle is associated with the working space of a hydraulic cylinder 53 controlling the rear axle interlocking mechanism, made in the form of two levers 54 and 55 mounted on the crane chassis 1 on pins 56 and 57 respectively, so as to be able to rotate freely in one sense and thrust against each other in the other sense. The free end of the lever 54 is associated with an axle 60 by means of a link 59, and the lever 55 is coupled with the hydraulic control cylinder 53, which may be associated with the frame of the chassis 1 if the crane incorporates one rear axle, or with the lever 55' of a second axle in the event of the crane being provided with two rear axles mounted on an axle 61. The hydraulic cylinder 53 may also be fitted with a strength transducer 62.

In compliance with one embodiment of the invention, the front axle transducer is installed on a hydraulic power cylinder kinematically associated

with the front axle imparting bearing pressure to the suitable transducer 10.

More specifically, the front axle transducer 10 (Figure 9) is installed in a hydraulic cylinder 63 with a movable member 64 thereof being coupled with a front axle 66 through a cable 65, and with the stationary member thereof being associated with the crane chassis 1.

All embodiments of a crane safe operation system disclosed hereinabove operate as follows.

With the crane resting on supports, working fluid flows into the hydraulic cylinders 35 to 38 (Figures 1 and 6). In this case several versions of positioning the crane with different load-lifting capabilities thereof are practicable. When the crane rests on supports, with the front axle and rear axles fully relieved, the crane stability is monitored by the support transducers 4 to 7. The criterion of the crane stability is relief of any of the neighbouring pairs of supports to a value ensuring the requisite margin of the crane stability. Consequently, as soon as the sum of the signals of any pair of transducers 4 to 7 (Figure 4) falls below the lower level of the comparator 20, the signal will arrive at the actuating device 13 through the units 21, 11 and 12 to inhibit the crane operation.

With the transducers 4 to 7 incorporating threshold converters, and the supports relieved, the contact pair 4(3), 7(1) (Figure 5) opens to deenergize the relay 27. This causes the contact pair 27(1) to open and deenergize the relay 28 with the contact pair of the actuating device thereof opening; the contact pair 28(1) opens likewise, turning off the green lamp 31 and turning on the red lamp 32 by means of the contacts 28(2), and the sound signal 34 with the aid of the contacts 28(3).

When the crane is set on supports, partially bearing on the front axle 66, the front axle transducer 10 joins in the monitoring the crane stability, particularly with the boom in the "back" position.

With no supports used, crane stability is monitored by the transducers 8, 9, 10. Load from the rear axle 60 (Figure 8) is transferred to the hydraulic cylinder 53 through the link 59 and two levers 54 and 55 to be fixed by the transducers 8 and 9 located on both sides of the crane chassis longitudinal axis, thereby monitoring the lateral stability of the crane. With the boom in the backward position, the crane stability is monitored by the transducer 10 of the front axle 66 (Figure 9).

Thus, the crane setting largely predetermines its load-lifting capabilities, which is monitored by the proposed system. In the event of the crane operating without the additional supports, rear axle interlocking mechanism should be actuated and a signal generated in the transducers 8, 9. Such being the case, the pointer of the indicator 24 (Figure 4) will stop against the zero mark, which corresponds to the crane no-support operation mode.

When the crane rests on supports with the axles relieved, its setting is determined by the combined load on the supports with the aid of the adder 26, designated by the readings of the indicator 24. With the crane properly positioned, its load-lifting capabilities can be utilized in the full degree. Improper setting of the crane, testified by the indicator 24, results in a lower load-lifting capacity thereof, which is taken account of by the system through limiting the boom radius.

In the event of gross violations of the crane positioning rules (failure to engage the spring interlocking mechanism, fixing the crane on its individual supports, use of supports as props, i.e. without properly relieving the crane axles) the system inhibits the crane operation.

With the crane operating with a sufficient margin of stability, e.g. with the boom in the "back" or "over support" position, individual units of the crane may be overloaded. In this case the crane load status is monitored by the transducers 14 to 16 installed in the boom lift hydraulic cylinder 43, the pressure line of the winch hydraulic motor 45 and the boom extension hydraulic cylinder 46. Such strength transducers may also be installed in the crane support hydraulic cylinders 35 to 38 (transducers 39 to 42) and the hydraulic cylinder 53 of the interlocking mechanism of the rear axle 60 (transducer 62). Besides, maximum inclination and wind transducers, and the like, may also be installed.

Thus, the crane safe operation system allows the crane capability as regards stability and strength of units to be used in a fuller degree, thereby increasing its load-lifting capacity and enhancing its efficiency, whereas monitoring the crane condition adds to its safe operation.

CLAIMS

1. A method for ensuring safe operation of a mobile boom crane, whereby signals are shaped in support transducers, to be converted into stability signals characterizing the crane stability, maximum levels of the converted signals ensuring the crane safe operation are generated and compared with the crane stability signals and, depending on the results of the comparison, an inhibit or enable signal is produced and fed to an actuating device of the crane, therewith additional signals are shaped in transducers fitted in the crane axles, to be converted into stability signals characterizing the crane stability, the stability signals formed in the transducers of the supports and axles are united in one of the groups characterizing the crane setting on the ground, and the stability signals are compared with the minimum levels thereof in each group, signals being simultaneously shaped in transducers installed in the crane units, to be converted into strength signals characterizing the strength of the crane units, and compared with the maximum preset levels, whereas the inhibit signals are generated in the event of one of the stability or strength signals exceeding its maximum level.

2. A method as claimed in claim 1, whereby the stability signals shaped in the transducers of supports and axles are united in one of the groups as regards signal intensity, with the first group being made up of the stability signals formed in the transducers of the supports and a front axle, the second group, of signals generated in the transducers of the front axle, the third group, of signals produced in the transducers of rear axles, located on one side of the

longitudinal axis of the crane chassis, and the fourth group, of signals formed in the transducers of the rear axles, located on the other side of the longitudinal axis of the crane chassis.

3. A system for implementing the method claimed in claim 1 or 2, comprising the stability transducers fitted in the supports in association, through adders and comparators, with the crane actuating device generating an inhibit or enable signal, therewith provided with the additional stability transducers installed in the crane axles, the strength transducers fitted in the crane units to indicate the maximum load of the crane, a unit to monitor the crane setting, whose input is connected to the stability transducers of the supports and axles through comparators of the minimum signal level and the output to one input of a control unit with the output thereof associated with the crane actuating device, and an OR unit with the input thereof connected to the strength transducers and the output thereof associated with the other input of the control unit.

4. A system as claimed in claim 3, wherein the stability and strength transducers are of the analog type, and the support transducers are paired in a manner that each pair out of the likely combinations of pairs of the support transducers is connected to its own adder, the input of the adder of the front support transducers is also associated with the transducer of the front axle, the output of each adder is associated with its own minimum signal level comparator, the outputs of the comparators are connected to the unit to monitor the crane setting through an OR circuit, and the transducer of the front axle, and also the transducers of the rear axles, located on both sides of the longitudinal axis of the crane chassis, are associated with their own comparators of the minimum signal level, with the outputs thereof being associated with the unit to monitor the crane setting through their own OR circuit, and all the strength transducers are connected to their own OR unit through their own maximum signal level comparators.

5. A system as claimed in claim 3, wherein the stability and strength transducers are provided with threshold converters comprising contact pairs, and closing contact pairs of supports are interconnected in parallel in accordance with the number of likely combinations of pairs of support transducers, and all pairs are series-connected in a support circuit with their own support relays, the pairs of front supports being connected in parallel with a closing contact pair of the transducer of the front axle, and the other closing contact pair of the transducer of the front axle and closing pairs of the transducers of the rear axles located on both sides of the longitudinal axis of the crane chassis are series-connected in a circuit of axles, the support relay contains the closing contact pair and make-before-break contacts with a common contact thereof connected to the input of one of the relays whose input is associated with the crane actuating device and two other contacts - an opening and a closing ones - are respectively connected to the axle circuit and the closing contact pair of the support relay, and the opening contact pairs of the strength transducers are series-connected with each other and with the input of a second relay with the output thereof associated with the crane actuating device.

6. A system as claimed in claims 3 to 5, wherein the support stability transducers are located in supports forming a trapezoidal figure with the larger base thereof formed by the crane front supports being located beyond the boom radius.

7. A system as claimed in any of the claims 3 to 6, wherein the transducers of the rear axles are mounted on a hydraulic power cylinder kinematically associated with the rear axle, wherethrough the bearing pressure of the rear axles is imparted to the suitable transducers.

8. A system as claimed in any of the claims 3 to 7, wherein the transducer of the front axle is mounted on a hydraulic power cylinder kinematically associated with the front axle imparting its bearing pressure to the suitable transducer.

9. A system as claimed in any of the preceding claims with reference to the accompanying drawings.

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